PLANAR SURFACE DETECTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent App. No. 62/620,971, filed on Jan. 23, 2018, U.S. Provisional Patent App. No. 62/775,336, filed on Dec. 4, 2018, and U.S. Non-Provisional patent application Ser. No. 16/254,858, filed on Jan. 23, 2019, which are hereby incorporated by reference in their entireties.

TECHNICAL FIELD

[0002] The present disclosure generally relates to plane detection, and in particular, to systems, methods, and devices for detecting horizontal and/or vertical planes.

BACKGROUND

[0003] As described herein, in order to provide immersive media experiences to a user, computing devices present computer-generated reality (CGR) that intertwines computer-generated media content (e.g., including images, video, audio, smells, haptics, etc.) with real-world stimuli to varying degrees—ranging from wholly synthetic experiences to barely perceptible computer-generated media content superimposed on real-world stimuli. To these ends, in accordance with various implementations described herein, CGR systems, methods, and devices include mixed reality (MR) and virtual reality (VR) systems, methods, and devices. Further, MR systems, methods, and devices include augmented reality (AR) systems in which computer-generated content is superimposed (e.g., via a transparent display) upon the field-of-view of the user and composited reality (CR) systems in which computer-generated content is composited or merged with an image of the real-world environment. While the present description provides delineations between AR, CR, MR, and VR for the mere sake of clarity, those of ordinary skill in the art will appreciate from the present disclosure that such delineations are neither absolute nor limiting with respect to the implementation of any particular CGR system, method, and/or device. Thus, in various implementations, a CGR environment include elements from a suitable combination of AR, CR, MR, and VR in order to produce any number of desired immersive media experiences.

[0004] In various implementations, a user is present in a CGR environment, either physically or represented by an avatar (which may be virtual or real, e.g., a drone or robotic avatar). In various implementations, the avatar simulates some or all of the physical movements of the user.

[0005] A CGR environment based on VR may be wholly immersive to the extent that real-world sensory inputs of particular senses of the user (e.g., vision and/or hearing) are completely replaced with computer-generated sensory inputs. Accordingly, the user is unable to see and/or hear his/her real-world surroundings. CGR environments based on VR can utilize (spatial) audio, haptics, etc. in addition to computer-generated images to enhance the realism of the experience. Thus, in various implementations, real-world information of particular senses provided to the user is limited to depth, shape, orientation, and/or layout information; and such real-world information is passed indirectly to the user. For example, the walls of real-world room are completely skinned with digital content so that the user cannot see the real-world walls as they exist in reality.

[0006] A CGR environment based on mixed reality (MR) includes, in addition to computer-generated media content, real-world stimuli received by a user either directly, as in the case of a CGR environment based on augmented reality (AR), or indirectly, as in the case of a CGR environment based on composited reality (CR).

[0007] A CGR environment based on augmented reality (AR) includes real-world optical passthrough such that real-world light enters a user's eyes. For example, in an AR system a user is able to see the real world through a transparent surface, and computer-generated media content (e.g., images and/or video) is projected onto that surface. In particular implementations, the media content is projected onto the surface to give the visual impression that the computer-generated media content is a part of and/or anchored to the real-world. Additionally or alternatively, the computer-generated image data may be projected directly towards a user's eyes so that real-world light and the projected light of the computer-generated media content concurrently arrive on a user's retinas.

[0008] A CGR environment based on composited reality (CR) includes obtaining real-world stimulus data obtained from an appropriate sensor and compositing the real-world stimulus data with computer-generated media content (e.g., merging the stimulus data with the computer-generated content, superimposing the computer-generated content over portions of the stimulus data, or otherwise altering the real-world stimulus data before presenting it to the user) to generated composited data. The composited data is then provided to the user, and thus the user receives the real-world stimulus indirectly, if at all. For example, for visual portions of a GGR environment based on CR, real-world image data is obtained using an image sensor, and the composited image data is provided via a display. Placing CGR objects in an unmapped or dynamic scene presents a challenge from at least a user experience perspective. If a CGR object is placed within a scene without a suitable virtual substrate, the CGR object may not be anchored to a real-world surface in the scene. As such, the CGR object may float in mid-air, occlude a real-world object, or collide with a real-world object. This produces a poor user experience that is neither lifelike nor believable. Accordingly, in various implementations, this challenge is solved by detecting planes within the scene and determining their extents in order to provide virtual substrates on which to place CGR objects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that the present disclosure can be understood by those of ordinary skill in the art, a more detailed description may be had by reference to aspects of some illustrative implementations, some of which are shown in the accompanying drawings.

[0010] FIG. **1** is a block diagram of an example operating environment in accordance with some implementations.

[0011] FIG. **2** is a block diagram of an example controller in accordance with some implementations.

[0012] FIG. **3** is a block diagram of an example HMD in accordance with some implementations.

[0013] FIG. **4** illustrates a scene with a handheld electronic device surveying the scene.